

Report to the Ranking Democratic Member, Committee on Transportation and Infrastructure, House of Representatives

September 2001

## AVIATION AND THE ENVIRONMENT

Transition to Quieter Aircraft Occurred as Planned, but Concerns About Noise Persist



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<b>Abstract</b> Aircraft noise is a major concern in communities around airports despite considerable reductions in such noise and a corresponding decrease in the population exposed to it. Moreover, concern about noise remains a constraint on efforts to expand airport capacity to meet the growing demand for air travel. The Congress has authorized the Federal Aviation Administration (FAA) to regulate aircraft noise. The Airport Noise and Capacity Act (ANCA) of 1990 established December 31, 1999, as the deadline for airlines to phase out the use of existing jet aircraft weighing more than 75,000 pounds that had not been modified to comply with current aircraft noise standards, called Stage 3. 1 Until ANCA's passage, only newly designed or newly manufactured aircraft were required to comply with the Stage 3 aircraft noise standards. Recently, the United States participated with other countries in the International Civil Aviation Organization (ICAO) to develop a more stringent aircraft noise standard for subsonic jets and large propeller-driven aircraft. On June 27, 2001, the ICAO Council approved the adoption of a new noise certification standard called Chapter 4.		
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## **Abbreviations**

ANCA	Airport Noise and Capacity Act of 1990
CAEP	Committee on Aviation Environmental Protection
FAA	Federal Aviation Administration
ICAO	International Civil Aviation Organization
MAGENTA	Model for Assessing Global Exposure to the Noise of Transport Aircraft



**United States General Accounting Office**  
Washington, DC 20548

September 28, 2001

The Honorable James L. Oberstar  
Ranking Democratic Member  
Committee on Transportation  
and Infrastructure  
House of Representatives

Dear Mr. Oberstar:

Aircraft noise is a major concern in communities around airports despite considerable reductions in such noise and a corresponding decrease in the population exposed to it. Moreover, concern about noise remains a constraint on efforts to expand airport capacity to meet the growing demand for air travel. The Congress has authorized the Federal Aviation Administration (FAA) to regulate aircraft noise. The Airport Noise and Capacity Act (ANCA) of 1990 established December 31, 1999, as the deadline for airlines to phase out the use of existing jet aircraft weighing more than 75,000 pounds that had not been modified to comply with current aircraft noise standards, called "Stage 3."<sup>1</sup> Until ANCA's passage, only newly designed or newly manufactured aircraft were required to comply with the Stage 3 aircraft noise standards. Recently, the United States participated with other countries in the International Civil Aviation Organization (ICAO) to develop a more stringent aircraft noise standard for subsonic jets and large propeller-driven aircraft. On June 27, 2001, the ICAO Council approved the adoption of a new noise certification standard called "Chapter 4."

Because the United States is considering moving to a new, more stringent noise standard, you asked us to provide a retrospective analysis of the transition to our current Stage 3 aircraft noise standards. This report discusses expectations, results, and issues raised by the transition.<sup>2</sup> To determine expectations and results, we reviewed the legislative history of

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<sup>1</sup>In the United States, noise standards are referred to as "Stages," whereas the International Civil Aviation Organization, the international body that sets international noise standards for aircraft, refers to them by the chapter of the ICAO document in which the standard appears. Unless otherwise noted, we refer to the standards in terms of Stages.

<sup>2</sup>The transition to more stringent noise standards involves technological and economic circumstances different than those that existed during the transition to Stage 3; therefore, the results from that transition may not be directly applicable.

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ANCA, as well as interviewed agency officials, industry representatives, and other aviation experts. Appendixes I and II discuss how noise standards are developed in the United States and internationally. To assess the reliability of the computerized model FAA uses to estimate the number of people exposed to various noise levels, we also interviewed agency officials, industry representatives, and other aviation experts. To estimate the airlines' costs to transition to the current aircraft noise standards, we developed a cost model. We compared and analyzed expectations with results to identify issues raised by the transition. See appendix III for more detailed information on our scope and methodology and appendix IV for a discussion of our model for estimating the costs to the airlines of the transition to the current U.S. standards.

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## Results in Brief

The transition to quieter aircraft required by ANCA was expected to benefit communities, airports, and airlines. According to agency officials and aviation experts, the levels of noise affecting communities near airports were expected to decline, providing a better quality of life for those communities. That decline was, in turn, expected to reduce community opposition to airport operations and expansion and to reduce the demand for funds provided for noise abatement through federal grants and user charges. The airlines expected the transition to facilitate their long-term planning for investment and fleet operations because the law mandating the transition to quieter aircraft resolved two key issues: (1) determining whether existing aircraft would have to comply with the quieter noise standards and (2) establishing guidelines to prevent the development of a "patchwork quilt" of airport access restrictions—such as limits on the number of Stage 2 aircraft that can land. However, expectations varied concerning the extent to which the airlines would replace rather than convert old aircraft to comply with the new noise requirements. Expectations of the airlines' transition costs also varied, ranging from as little as \$17 million to as much as \$175 billion. In 1991, we estimated that these costs would range between \$2.1 billion and \$4.6 billion in 1990 dollars.<sup>3</sup>

The results expected from the transition to quieter aircraft were partially realized. The transition occurred as planned and considerably reduced the population exposed to levels of noise that FAA considers incompatible

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<sup>3</sup>See *Aviation Noise: Costs of Phasing Out Noisy Aircraft* ([GAO/RCED-91-128](#), July 2, 1991).

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with residential living. FAA estimated a decline from 2.7 million people in 1990 to about 440,000 people in 2000. Nevertheless, noise concerns remain an impediment to airport expansion, and the demand for federally authorized support for noise abatement efforts has continued.

Furthermore, the airlines' long-term plans for their fleets may be in jeopardy because an association representing major airports and some individual airports are recommending the early retirement of aircraft within 5 decibels of Stage 3 noise standards. Many of these aircraft have engines that were technologically converted, "hushkitted," to comply with current standards. The law mandating the transition did, however, limit the implementation of new airport access restrictions. We currently estimate that the airlines' costs directly attributable to complying with the transition to quieter aircraft noise standards ranged from \$3.8 billion to \$4.9 billion in 2000 dollars.

The results of the transition, especially compared with the expectations, raise some issues that may be relevant to the future consideration of new aircraft noise standards. In particular, we identified two key issues for review by the aviation community. First, why does concern about noise continue to generate substantial opposition to airport operations and expansion after such a major decline in the number of people living in areas exposed to incompatible levels of noise? Even though fewer people are exposed to aircraft noise, according to 35 of the 50 busiest commercial passenger airports we surveyed in the 1999-2000 period, over half of the noise complaints in the preceding year came from persons living in areas exposed to noise levels that FAA considers compatible with residential living. Second, as noise levels decrease, how can local governments be encouraged to take responsibility for minimizing the exposure of residents to noise by preventing new residential development from encroaching on airports, when such areas may later become incompatible as airport operations and noise increase? If people are allowed to move into areas close to an airport, they may later find themselves exposed to noise levels that FAA considers incompatible with residential living as the airport's operations grow to meet the rise in demand. Furthermore, residential development in such areas could generate new opposition to airports operations and future expansion plans.

We provided the Department of Transportation, the Environmental Protection Agency, the National Aeronautics and Space Administration, Airports Council International-North America, the Air Transport Association of America, and the American Association of Airport Executives with copies of a draft of this report for their review and comment. The Environmental Protection Agency, the National

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Aeronautics and Space Administration, and the American Association of Airport Executives provided no comments.

We received oral comments from the Department of Transportation, the Airports Council International-North America, and the Air Transport Association. Officials from these organizations generally agreed with the facts presented in the report. FAA's Office of Energy and Environment, Department of Transportation, provided a revised estimate of the number of people exposed to noise levels that FAA considers incompatible with airport operations. This estimate is based on recent updates to the model used for this purpose. The Senior Vice President of Technical and Environmental Affairs, Airports Council International, clarified the Airports Council's position with respect to phasing out older, noisier aircraft. The Airports Council called for retiring aircraft on the basis of the noise they produce (those that are within 5 decibels of the Stage 3 noise standards) rather than on a design feature such as hushkitted engines. The Air Transport Association's Assistant General Counsel cautioned that the results of the transition from Stage 2 to Stage 3 aircraft are not directly applicable to a transition from Stage 3 to Stage 4 because of different economic and technological circumstances. We revised the report to incorporate these comments and other clarifying and technical comments as appropriate.

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## Background

Aircraft noise standards establish the noise limits that civil subsonic jet aircraft are permitted to generate for takeoff, landing, and sideline measurements.<sup>4</sup> These standards are based on an aircraft's weight and number of engines. In general, they allow heavier aircraft and those with more engines to generate more noise than lighter aircraft and those with fewer engines. The noise generated by an aircraft generally correlates to the thrust powering the aircraft. The heavier the aircraft, the more thrust it needs.

In the United States, the Federal Aviation Act of 1958, as amended in 1968, gives FAA the authority to regulate aircraft noise.<sup>5</sup> (See app. I for a description of the development and implementation of U.S. aircraft noise standards.) Under that act, FAA issued regulations in 1969 that established

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<sup>4</sup>Sideline noise is measured at a point parallel to the flight path where the noise level is the greatest.

<sup>5</sup>49 U.S.C. 44715.

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noise standards for new designs of civil subsonic jet aircraft. In 1973, FAA amended its regulations to apply the noise standards to all newly manufactured aircraft, no matter when the aircraft were designed. In 1977, additional amendments established lower noise standards for all new aircraft, as well as the concept of “noise Stages.” Aircraft meeting the original 1969 standards were categorized as “Stage 2” aircraft; those meeting the more stringent 1977 standards, the current standards, were categorized as “Stage 3” aircraft; and aircraft meeting neither standard were categorized as “Stage 1” aircraft.

In 1976, FAA prohibited all Stage 1 subsonic jet aircraft weighing more than 75,000 pounds from flying into or out of U.S. airports after January 1, 1985, unless the aircraft had been converted to meet the quieter noise standards.<sup>6</sup> In 1990, ANCA required all existing civil subsonic jet aircraft weighing more than 75,000 pounds to comply with the current U.S. Stage 3 noise standards by December 31, 1999, or be retired from service. To meet this requirement, the engines on Stage 2 aircraft could be modified or replaced. The Stage 3 standards for takeoff, landing, and sideline measurements range from 89 to 106 decibels, depending on the aircraft’s weight and number of engines.<sup>7</sup>

FAA regulations governing the transition to meet Stage 3 noise standards went into effect on September 25, 1991, and offered two options for meeting the December 31, 1999, deadline. One option permitted a phased reduction in Stage 2 aircraft (phaseout), while the other called for a phased increase in the proportion of Stage 3 aircraft in the total fleet (phase-in). According to FAA, these options would result in significant cost savings for the industry while still preserving environmental gains. Although the greatest environmental gains would occur near the end of the phase-out period, FAA noted that both approaches offered steady progress throughout the decade toward an all-Stage-3 fleet. Phaseout of older, noisier Stage 1 and 2 aircraft was possible, in part, because the National Aeronautics and Space Administration, in cooperation with the aviation industry, developed new, quieter engines. The National Aeronautics and

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<sup>6</sup>However, the Aviation Safety and Noise Abatement Act of 1979 directed FAA to grant exemptions from compliance until January 1, 1988, to civil subsonic jet aircraft with two engines and fewer than 100 passenger seats.

<sup>7</sup>The noise measurement level is defined in terms of the “effective perceived noise level,” which includes a correction for tones and takes into account the duration of the noise event. A food blender makes about 88 decibels of noise, while a rock band playing indoors makes about 108 to 114 decibels of noise.

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Space Administration, in cooperation with FAA and the aviation industry, is continuing to develop new technologies to reduce the impact of aircraft noise, although they have indicated that there are no significant breakthroughs in sight.

FAA has several federal programs that address noise issues associated with civilian airports. Through one of these programs, FAA controls aircraft noise by regulating aircraft operations. FAA also administers two programs that fund noise mitigation projects. The Airport Improvement Program provides federal grants—funded by congressional appropriations from the Airport and Airway Trust Fund—for developing airport infrastructure, including projects that reduce airport-related noise or mitigate its effects. Grants are made using either funds subject to apportionment or discretionary funds. Funds subject to apportionment are distributed by a statutory formula to commercial service airports according to the number of passengers served and the volume of cargo moved,<sup>8</sup> and to the states according to a percentage of the total amount of the appropriated funds. Discretionary funds are, for the most part, those funds remaining after funds subject to apportionment are allotted and certain other amounts are “set aside” for special categories, including noise-related projects. The Passenger Facility Charge program is a voluntary program that enables airports to impose a fee of up to \$4.50 on each boarding passenger. The airports retain the money for airport infrastructure projects. Airports wishing to participate in the program must seek FAA’s approval both to levy the fee and to use the revenues for particular development projects. Both programs include noise reduction projects such as soundproofing buildings (including homes and schools) and land acquisition, which includes acquiring homes and relocating the people displaced to quieter communities.

ANCA required FAA to establish regulations on airport noise and access restrictions on the operations of Stage 2 and Stage 3 aircraft.<sup>9</sup> Existing access restrictions were grandfathered, permitting them to remain in effect. To restrict the access of Stage 2 aircraft, an airport has to publish the proposed restrictions at least 180 days before they go into effect. The airport is also required to publish other information with the restrictions such as cost-benefit analyses of the proposed restrictions and any

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<sup>8</sup>Commercial service airports handle all regularly scheduled commercial airline traffic and have at least 2,500 enplanements (boarding by passengers) annually.

<sup>9</sup>FAA established these regulations in 1991 with the promulgation of 14 C.F.R. Part 161.

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alternatives considered. If the restrictions are to apply to Stage 3 aircraft, they must be approved by FAA or agreed to by the airport and all the aircraft operators at an airport. To approve restrictions, FAA must find that the proposed restrictions (1) are reasonable, nonarbitrary, and nondiscriminatory; (2) do not create an undue burden on interstate or foreign commerce; (3) are not inconsistent with maintaining the safe and efficient utilization of the navigable airspace; (4) do not conflict with any existing federal statute or regulations; (5) have been adequately provided to the public for comment; and (6) do not create an undue burden on the national aviation system.<sup>10</sup>

The primary responsibility for integrating airport considerations into local land-use planning rests with local governments—presenting a difficult problem for many airports, because they often do not have control over development in surrounding communities. However, airports are held accountable by these communities when aircraft noise adversely affects uses such as schools and residences built close to airports. FAA set the standards that airports use to measure the level of noise to which communities around airports are exposed over time and had issued guidelines that identify land uses that would and would not be compatible with the noise generated by a nearby airport's operations.

ICAO is the international body charged with ensuring the safe and orderly growth of international civil aviation throughout the world. One of ICAO's functions is to set international noise standards for aircraft. The primary purpose of establishing noise standards is to reduce aircraft noise. This noise reduction, when combined with other noise reduction measures, can reduce the number of people exposed to significant levels of aircraft noise. Any new standard must receive the approval of two-thirds of the members of ICAO's Council, one of whom is the United States, and the standard becomes effective unless it is then disapproved by a majority of ICAO's members through the Assembly.<sup>11</sup> (See app. II for a description of the development of international aircraft noise standards.) Member nations then implement the new standards through their own political and legal

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<sup>10</sup>49 USC 47524 (c) (2).

<sup>11</sup>The Assembly, composed of representatives from all 187 member countries, is the sovereign body of ICAO. It meets at least once every 3 years, reviewing in detail the work of ICAO and setting policy for the coming years. Each member country is entitled to one vote, and decisions of the Assembly are taken by a majority of the votes cast except when otherwise provided in the Convention. In practice, according to an FAA official, the Assembly usually reaches decisions by consensus.

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processes. International recognition of aircraft noise standards is a cornerstone of the international system of air travel, enabling airlines to plan and operate their fleets more efficiently than if there were a patchwork of national noise standards or operating restrictions.

In January 2001, ICAO's Committee on Aviation Environmental Protection (CAEP), a technical body that recommends international aircraft noise standards for the organization, endorsed a balanced approach to noise management that included such things as the reduction of noise from aircraft, improved land-use planning and control around airports, and the use of aircraft noise abatement procedures and aircraft operating restrictions. To reduce aircraft noise, CAEP recommended, and the Council adopted,<sup>12</sup> new Chapter 4 noise standards that are 10 decibels lower, on a cumulative basis, than the Chapter 3 standards.<sup>13</sup> The standards will apply to new designs submitted on or after January 1, 2006. On the basis of a cost-benefit analysis, CAEP recommended that there be no global phaseout of aircraft meeting Chapter 3 noise standards. CAEP considered the question of operating restrictions on Chapter 3 aircraft but reached no final conclusion. ICAO's members are expected to make a final decision on these issues when the Assembly meets from September 25 to October 5, 2001. FAA is the official U.S. representative to CAEP. Representatives from the State Department, the Environmental Protection Agency, the U.S. aviation industry, and environmental groups also participate in CAEP's work.

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<sup>12</sup>Because it is up to each member country to adopt noise standards, FAA has begun the rulemaking process to adopt the new standard.

<sup>13</sup>This cumulative noise basis is the total difference between the measured noise level and the Chapter 3 noise limits at three different points: takeoff, approach, and sideline. The new standard requires at least a 2 decibel reduction at each of these points. For example, if the takeoff noise level is 3 decibels below the takeoff limit, the approach noise level is 3 decibels below the approach limit, and the sideline noise level is 4 decibels below the sideline limit, then the cumulative margin would be 10 decibels.

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## Transition to Quieter Aircraft Was Expected to Benefit Communities, Airports, and Airlines

The mandated transition to quieter aircraft was expected to reduce the number of people exposed to noise levels that FAA considers incompatible with residential living, to facilitate needed airport expansion, and to enable airlines to embark on long-term planning for investing in and operating their fleets. Expectations concerning how the airlines would comply with the mandated transition, and what that transition might cost the airlines, varied.

The mandated transition to quieter aircraft was expected to reduce the overall levels of noise to which nearby communities were exposed, thereby reducing the annoyance caused by airport-generated noise and improving the quality of life for people living in those communities. Communities near airports are exposed to noise directly attributable to airport operations—primarily from aircraft taking off and landing.<sup>14</sup> The impact of such noise on communities is usually analyzed in terms of the extent to which the noise annoys people by interfering with their normal activities, such as sleep, relaxation, speech, television, school, and business operations. According to FAA's final rulemaking implementing the transition, the number of people living in areas exposed to noise levels that were incompatible with residential living was expected to fall from about 2.7 million in 1990 to about 400,000 in 2000, when the mandated transition to quieter aircraft was complete.<sup>15</sup>

Less noise from airport operations was expected to reduce community opposition to airport expansion. ANCA, in particular, acknowledged that aviation noise was linked to airport expansion and community opposition to that expansion. The findings of ANCA state that aviation noise management is crucial to the continued increase in airport capacity and that community noise concerns can be alleviated, in part, through the use of quieter aircraft and revenues for noise management. At the time the transition was mandated, aircraft noise was a major impediment to increasing airport capacity, particularly if the increase was to be provided by constructing new runways. New capacity was needed at the time because the demand for air travel was causing increasing delays—in 1988, 21 airports experienced more than 20,000 hours of delays. Airports were thus expected to benefit from the transition to quieter aircraft by being able to plan for growth and develop the capacity needed to meet the rising

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<sup>14</sup>Engine maintenance and the taxiing of aircraft on runways are other activities that contribute to airport noise.

<sup>15</sup>56 Fed. Reg. 48628, Sept. 25, 1991.

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demand for air travel. The lower noise levels were also expected to reduce the airports' need for federal investments in noise abatement programs.

ANCA's passage was also expected to provide a stable environment that would enable the airlines to develop long-term business plans for their fleets. Ongoing uncertainty about whether existing aircraft would be required to comply with Stage 3 noise standards and the promulgation of a plethora of airport access restrictions had been impeding the airlines' development of long-term investment and operating plans. By 1990, many communities had established restrictions on the use of their airports—such as limits on the number of Stage 2 aircraft that could land—to reduce the amount of noise the airports were generating. Additionally, before ANCA's passage, many airports were planning to adopt use restrictions in the absence of a federally mandated phaseout of Stage 2 aircraft.<sup>16</sup> The airlines believed that a resulting "patchwork quilt" of restrictions would likely produce a de facto phaseout of Stage 2 aircraft by 2000.

ANCA settled both of these issues in 1990 by mandating that heavier aircraft meet Stage 3 standards by December 31, 1999, and by establishing an FAA review process that airports had to follow if they wanted to adopt new noise or access restrictions. With these decisions made, the airlines expected to be able to develop long-term fleet plans that could include operating Stage-3-compliant aircraft for their useful lives.

At the time of ANCA's passage, there were varying assumptions as to how the airlines would comply with the transition. Some in the aviation community thought the airlines would comply with the transition largely by purchasing new aircraft rather than converting existing aircraft to meet Stage 3 noise standards. Conversion could be achieved by replacing an aircraft's engines or by installing a noise reduction technology known as a "hushkit."<sup>17</sup> Because new aircraft were generally quieter than aircraft with hushkits, replacing aircraft was expected to provide a greater reduction in aircraft noise. Some anticipated that aircraft replacement would be the primary means for complying with Stage 3 standards because of high fuel prices at the time the law was passed; new Stage 3 aircraft were generally

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<sup>16</sup>See GAO/RCED-91-128, July 2, 1991.

<sup>17</sup>An airline representative told us that at the time ANCA was passed, hushkits had not yet been certified for most models of Stage 2 aircraft and there was concern that hushkits might affect the weight and performance of the aircraft as had occurred with hushkits used to meet the Stage 2 standards.

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more fuel efficient than existing Stage 2 aircraft. Others in Congress and the aviation community, however, noted that hushkitting was as likely an expectation for compliance as aircraft replacement.

At the time the transition was mandated, estimates of the airlines' cost to comply with the transition ranged from \$17 million to \$175 billion. The wide variation depended largely on whether an analysis assumed modification, full cost for replacement, and/or fleet growth. In 1991, we reported on the assumptions and methodologies of four major studies.<sup>18</sup> Two of the studies were limited to a single segment of the aviation community—one to major passenger airlines and the other to freight aircraft. A third study used the purchase price of an aircraft as the cost of meeting Stage 3 noise standards—a cost we considered excessive. A fourth study, the one offered by FAA, was more comprehensive—including the domestic jet fleet for both passenger and cargo air traffic—and incorporated generally reasonable assumptions in its methodology. Using FAA's methodology as a base and making certain changes in the assumptions, such as the discount rate used to compute future expenditures and costs savings, we estimated at the time that complying with the Stage 3 noise standards would cost the airlines from \$2.1 to \$4.6 billion in 1990 dollars.<sup>19</sup> Our low estimate assumed all aircraft owners would adopt the least expensive approach to compliance for each aircraft, whereas our high estimate assumed premature replacement of all aircraft.<sup>20</sup>

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## Expectations Were Partially Realized

The results anticipated from the transition to meet Stage 3 noise standards were partially realized. The transition to quieter aircraft worked smoothly and was achieved within the required time frame. Also, FAA estimates that the transition to aircraft compliant with Stage 3 noise standards considerably reduced the population exposed to levels of noise from

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<sup>18</sup>The estimates from these studies ranged from \$17 million to \$59.6 billion. The estimate of \$175 billion was presented by the Air Transport Association of America, Inc. (hereafter referred to as the Air Transport Association) in testimony on October 2, 1990, as the total cost to be borne in the United States to achieve an all-Stage-3 fleet, including growth (see *Statement of Robert J. Aaronson, President, Air Transport Association Before the Subcommittee on Aviation, House Committee on Public Works and Transportation, House of Representatives (Oct. 2, 1990)*).

<sup>19</sup>GAO/RCED-91-128, July 2, 1991.

<sup>20</sup>The premature replacement cost used in our estimate was \$2.2 million per aircraft in 1990 dollars. Premature replacement costs are substantially less than the price of a new aircraft.

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airport operations that FAA considers incompatible with residential living. Nevertheless, community opposition remains the primary impediment to airport expansion, and concern about noise is the reason most frequently cited as the basis for such opposition. Despite the significant decrease in the population exposed to incompatible noise, the demand continues for federally authorized support for noise mitigation efforts that are provided through a federal grant program and a federally authorized passenger boarding fee. Furthermore, while the adoption of new airport noise and access restrictions has been limited since the law was passed,<sup>21</sup> the airlines' long-term plans for their fleets may nevertheless be jeopardized by challenges to the continued use of older Stage 3 aircraft that are noisier than those newly manufactured. We currently estimate that the airlines' costs directly attributable to complying with the transition to quieter aircraft noise standards (i.e., the cost of hushkitting or the incremental cost of financing a new aircraft early, whichever was lower) ranged from \$3.8 billion to \$4.9 billion in 2000 dollars.

According to FAA, expectations for the reduction in the number of people living in areas incompatible with airport-generated noise levels have essentially been met.<sup>22</sup> FAA estimates that in 2000 there were about 440,000 people living in areas exposed to incompatible noise levels, only a slightly higher number than FAA originally estimated, and a considerable reduction from FAA's 1990 estimate of 2.7 million. FAA's current population exposure estimates are based on the use of what FAA and ICAO consider to be a substantially credible model that is used to project the number of people exposed to various airport-generated noise levels—the Model for Assessing Global Exposure to the Noise of Transport Aircraft (MAGENTA).

We discussed the MAGENTA model with FAA to assure ourselves that the model's estimate of the number of people living in areas exposed to incompatible noise levels was reliable. According to a FAA official, the model was extensively reviewed and vetted through ICAO's MAGENTA Working Group. This official also said that it is the only model that is available to do this type of estimate. The development and testing phases

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<sup>21</sup>No Stage 3 restrictions have been implemented under ANCA.

<sup>22</sup>See *Aviation and the Environment: FAA's Role in Major Airport Noise Programs* ([GAO/RCED-00-98](#), Apr. 28, 2000) for a discussion of the issues concerning the definition of incompatible land use and the measurement methods used to identify community exposure and annoyance levels.

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of the model were completed last year and used by ICAO's environmental technical experts to evaluate various noise issues. FAA's estimates using MAGENTA were based on the best available data, which FAA is currently updating. FAA recently updated the U.S. version of MAGENTA with new airport operational data and 2000 census data. The net effect of this update is a new estimate of 440,000 people exposed in 2000 instead of 448,000 as estimated earlier. FAA is also updating two other data inputs to further improve the accuracy of the estimate. These data inputs are the type of aircraft using each airport and new runways or runway extensions added since the mid-1990s. While the updated data may produce some changes in the estimated number of persons exposed to incompatible levels of noise, FAA and others believe these changes are not likely to be significant.

Although it is unclear whether community annoyance declined with lower noise levels, opposition to airport expansion continues. In our 1999-2000 survey of the 50 busiest commercial passenger airports, noise issues were identified as the primary environmental concern and challenge for airports.<sup>23</sup> We found that although airports had implemented various measures to reduce the impact of aircraft noise, community concerns persisted.

While the extent to which areas around airports have been built up since the transition to an all-Stage-3 fleet is not known, strong pressure exists to develop residential areas around heavily used airports, particularly in metropolitan areas with more than 50,000 people. Our 1999-2000 survey found that officials from 13 of the nation's 50 busiest commercial service airports view increases in the residential population near their airport as a major concern. Thirty-five of the airports reported that over half of the noise complaints in the preceding year had come from persons living in areas whose noise levels FAA considers compatible with residential development. According to an October 2000 report by the Airports Council International-North America, an association representing airports, noise remains the single biggest impediment to increasing airport capacity across the country.<sup>24</sup> More recently, FAA found that public opposition to

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<sup>23</sup> *Aviation and the Environment: Airport Operations and Future Growth Present Environmental Challenges* ([GAO/RCED-00-153](#), Aug. 30, 2000).

<sup>24</sup> *The Next Stage in Noise Abatement Policy: ACI-NA's Plan for A Quieter Environment* (Airports Council International-North America, Oct. 2000).

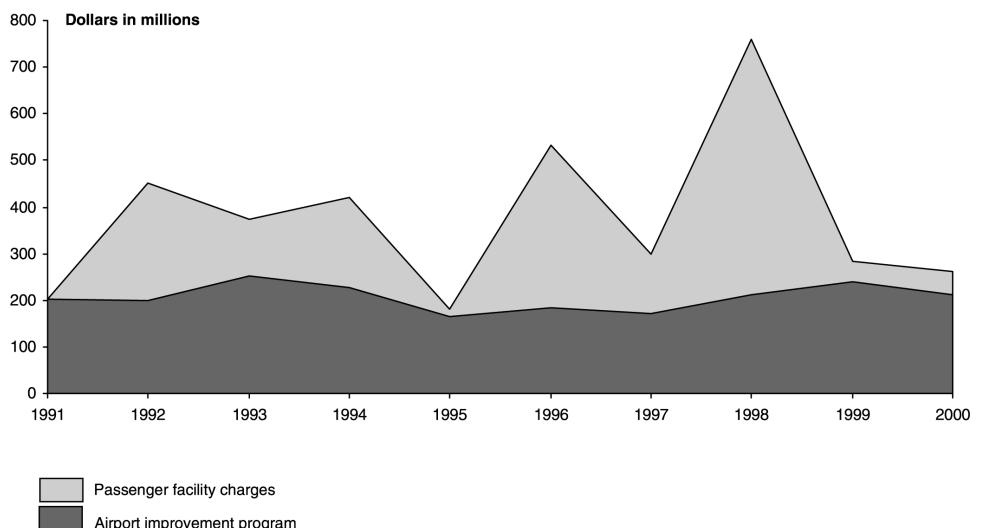
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airport expansion continues to rise, with noise cited as the primary reason.<sup>25</sup>

The reduction in the population exposed to incompatible noise levels, as defined by FAA, has also not led to a decrease in the demand for federally authorized funding for noise projects. As figure 1 shows, the demand for funds for noise abatement continued throughout the decade, albeit at varying levels from year to year.

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**Figure 1: Federally Authorized Noise Abatement Funding Since the Passage of ANCA, Fiscal Years 1991-2000**



Note: Data for Airport Improvement Program funds are the grant amounts for noise abatement projects by fiscal year. These grant amounts are primarily determined by the amount set aside each year for noise abatement from FAA's appropriations. For fiscal year 2001, 34 percent of the Airport Improvement Program's funds available for discretionary airport grants (or \$315 million) was targeted for noise abatement projects. Data for passenger facility charge funds represent the amount approved for collection for noise abatement in a given fiscal year. Peaks and valleys occur in the data because of differences in the amount of funds that airports happen to request for noise abatement in a given year. While FAA approves a project only once, funds are generally collected and spent over many years. FAA first approved passenger facility charge collections in fiscal year 1992.

Source: GAO's compilation of data from FAA.

ANCA did limit the implementation of new airport noise and access restrictions. According to FAA, since ANCA's passage in 1990, no formal

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<sup>25</sup>Report to the U.S. Congress on Environmental Review of Airport Improvement Projects, (U.S. Department of Transportation, May 2001).

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proposals for new Stage 3 restrictions have been completed under ANCA's implementing regulations.<sup>26</sup> FAA has been asked to review draft analyses of proposed restrictions at (1) Pease Airport in New Hampshire to restrict the nighttime scheduling of Stage 3 aircraft, (2) Burbank Airport in California to implement a nighttime curfew affecting all aircraft operating at the airport, and (3) Kahului Airport in Hawaii to phase out Stage 2 aircraft.<sup>27</sup> FAA is currently reviewing a proposed restriction by the Naples Municipal Airport in Florida to ban Stage 2 aircraft that weigh less than 75,000 pounds.<sup>28</sup> In addition, two new proposed restrictions on Stage 2 aircraft were withdrawn.<sup>29</sup>

The airlines have met the deadline for completing their transition to meet Stage 3 noise standards. According to the draft *1999 Progress Report on the Transition to Quieter Airplanes*, FAA is satisfied that all known affected aircraft operators are in compliance with the December 31, 1999, statutory requirements. By the end of 1999, the 221 active operators' fleets included only Stage-3-compliant aircraft.

Despite full compliance with the transition to Stage 3, the airlines' long-term fleet plans may now be in jeopardy. Some in the aviation community have called for the retirement of aircraft that are within 5 decibels of Stage 3 standards, many of which are hushkitted, even though the aircraft meet Stage 3 standards. The Airports Council International-North America reports that the noise levels produced by hushkitted aircraft meet the Stage 3 standard or are 1 to 5 decibels quieter than it, while newly manufactured Stage 3 aircraft are as much as 10 to more than 20 decibels quieter than the standard.<sup>30</sup> As a result, Airports Council officials noted

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<sup>26</sup>14 C.F.R. 161 establishes the process for FAA's review of airport access and noise restrictions.

<sup>27</sup>Hawaii and Alaska are exempt from the ANCA Stage 2 aircraft phaseout requirements.

<sup>28</sup>ANCA did not require a mandatory transition of aircraft weighing less than 75,000 pounds to meet Stage 3 noise standards.

<sup>29</sup>The Minneapolis-St. Paul International Airport and the San Francisco International Airport proposed restrictions on Stage 2 aircraft weighing over 75,000 pounds before the ANCA phaseout date of December 31, 1999. Both airports withdrew their proposals. In late 1999, the Minneapolis-St. Paul International Airport banned any Stage 2 aircraft that might receive phaseout waivers under ANCA. This restriction had no effect because FAA did not grant waivers.

<sup>30</sup>For example, a hushkitted Boeing 727 is about 2 decibels quieter than the Stage 3 standard, while a newer Boeing 757 is up to 20 decibels quieter than the Stage 3 standard.

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that while noise levels declined following the transition, they did not decline as much as they would have if aircraft had been replaced rather than converted. Noise is still a problem in part because of these older, noisier aircraft. Therefore, the Airports Council and some individual airports are recommending retiring aircraft within 5 decibels of Stage 3 limits.

Airline representatives have noted that there have been an increasing number of requests for “voluntary” phaseouts of hushkitted aircraft at individual airports, along with operating procedures or runway use restrictions that target hushkitted aircraft. According to these representatives, this is a major concern for commercial passenger airlines because they developed their Stage 3 compliance strategies and long-term fleet plans with the expectation that those aircraft would be available for their useful lives; therefore, any premature retirement of hushkitted aircraft would have a further economic impact on the industry. Additionally, a cargo industry representative noted that cargo airlines are currently dependent on older aircraft that are hushkitted to stay in business.

More recently, two estimates of the cost of complying with the mandated transition to Stage 3 noise standards have been completed. In 1999, the Air Transport Association, an association representing major U.S. commercial airlines, commissioned an analysis of the airlines’ costs for complying with the mandated transition. That analysis concluded that these costs were about \$32 billion in 1999 dollars, not including the cost of fleet growth. Another estimate by a major aircraft engine manufacturer placed the costs to airlines at about \$15.5 billion. Both of these cost analyses, however, included the full cost of aircraft purchased to replace older Stage 2 aircraft. We believe that including the full replacement cost of an aircraft exceeds the cost directly attributable to compliance with the mandated transition. An airline representative noted that some carriers chose to incur the additional cost of replacing their aircraft, in part, to respond to their customers’ environmental concerns.

On the basis of a model we developed, we estimated that the airlines’ costs directly attributable to the mandated transition ranged from a low of \$3.8 billion to a high of \$4.9 billion in 2000 dollars. We determined that the appropriate cost that could be attributed to compliance with the noise standards was the cost for the conversion of an aircraft—that is, by

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hushkitting the engines—or the incremental capital cost of financing the early replacement of an aircraft, whichever cost was lower.<sup>31</sup> This estimate is based on 2,372 Stage 2 aircraft over 75,000 pounds in the U.S. fleet on November 5, 1990, the date ANCA became law. We applied the actual hushkit cost, or range of costs, for a particular model of aircraft and the cost of installing the hushkit.<sup>32</sup> (See app. IV for a more detailed discussion of our cost methodology.) We adopted this approach as the way to reflect only the cost of compliance, although many carriers opted to exceed FAA's requirement and incurred significant additional costs in so doing.<sup>33</sup> Since hushkitting was expected and proved to be available for almost all types of aircraft, when the airlines chose more costly methods to achieve compliance—such as replacing the engines or purchasing new aircraft—we attributed that choice to other economic reasons or benefits, such as improved fuel efficiency, lower maintenance costs, and tax advantages.

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## Transition Raises Two Key Issues

The transition to quieter aircraft worked smoothly, was achieved within the required time frame, and was successful in reducing the number of residents living in areas FAA considered incompatible for residential use. However, concerns about aircraft noise continue to be a constraint on future airport expansion. Also, FAA and other officials are concerned that as flights increase to meet the expected growth in travel, the population exposed to incompatible noise levels may rise again around some airports. Thus some of the gains obtained by the transition to quieter aircraft may be eliminated.

Our review of the results of the transition, however, especially compared with the expectations, raises two key issues: (1) Why does concern about noise continue to generate substantial opposition to airport operations and

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<sup>31</sup>We estimated that the cost of capital to the airline industry in 1999 was 7.8 percent. Our capital cost estimate was calculated using a weighted average of the costs of receiving financing from both the debt and equity markets where the weights are the proportion of total capital obtained from each. This estimate relied on information from Value Line, a common financial information source, for a representative firm (United Airlines) in the airline industry.

<sup>32</sup>For those aircraft for which we could not obtain specific hushkit model cost data, we applied the average cost, or range of costs, of those hushkits available for the aircraft model and type.

<sup>33</sup>We did not include the cost savings associated with a new aircraft due to factors such as better fuel economy or a smaller crew. We also did not include increased costs associated with hushkitting an aircraft such as downtime and fuel burn increases.

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expansion after such a major decline in the number of people living in areas exposed to incompatible levels of noise? and (2) As noise levels decrease, how can local governments be encouraged to take responsibility for minimizing the exposure of residents to noise by preventing new residential development from encroaching on airports, when such areas may later become incompatible as airport operations and noise increase? Table 1 discusses these issues and identifies some specific questions for the aviation community to explore to address these issues.

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**Table 1: Issues Raised by the Transition to Quieter Aircraft Noise Standards**

Issue	Context of issue	Discussion
1. Why does concern about noise continue to generate substantial opposition to airport operations and expansion after such a major decline in the number of people living in areas exposed to incompatible levels of noise?	As required by law, FAA has selected a single method for measuring the noise exposure of communities near airports and determined what kinds of development are compatible with various noise exposure levels. FAA's selection was reinforced by an interagency review of noise measurement options. Federal agencies can use additional information when implementing programs that use measures of noise exposure levels. FAA's designation of when noise levels are compatible with residential development helps the agency set priorities for funding noise abatement activities through the Airport Improvement Program and passenger facility charges.	Although the number of people living in areas exposed to incompatible noise levels, according to FAA's designation, has dropped substantially since the transition to quieter aircraft, aircraft noise continues to be a major impediment to airport expansion. Moreover, complaints not only continue but also emanate from areas exposed to noise levels FAA considers compatible with residential dwelling—35 of the 50 busiest commercial passenger airports reported to us in a 1999-2000 survey that over half of the noise complaints in the preceding year came from persons living in compatible areas. <ul style="list-style-type: none"><li>• Can noise reduction alone, or reduction to a specific level, substantially mitigate opposition to airport expansion?</li><li>• Is there a standard, other than the standard FAA currently uses to measure noise levels, that would better gauge opposition to aircraft noise?</li></ul>
2. As noise levels decrease, how can local governments be encouraged to take responsibility for minimizing the exposure of residents to noise by preventing new residential development from encroaching on airports, when such areas may later become incompatible as airport operations and noise increase?	Zoning authority lies with states and communities, not the federal government. While FAA regulations establish noise exposure levels compatible with various kinds of development, FAA has no authority to decide what development is authorized. However, FAA policy prohibits using Airport Improvement Program funds for remedial noise mitigation—such as soundproofing buildings—for buildings that were known to be located in areas incompatible with prevailing noise exposure levels before they were built. FAA uses noise exposure levels to set priorities for funding noise abatement projects. This results in the approval of few noise abatement projects in areas where land uses are considered compatible with residential development.	Areas once considered incompatible with residential development under FAA's designation of compatible noise levels may now be quiet enough for residential development. Many in the aviation community are concerned that new residential development has occurred and may continue to occur in those areas. However, as the demand for air travel grows, increasing the number of takeoffs and landings at airports, noise exposure levels may begin to rise around some airports. People moving closer to an airport may then find themselves living in areas whose noise levels FAA considers incompatible with residential development. Residential development in those areas could also generate new opposition to airport operations and future airport expansion plans. Furthermore, such development could create a demand for additional noise abatement efforts funded through federally authorized programs. While FAA has launched a land-use planning initiative to help communities consider airport issues in their planning efforts, that initiative has focused on improving the communication of the agency's noise policies and noise compatibility information in order to help communities and airports work together to minimize the noise impact of airports. <sup>a</sup> The extent to which areas around airports have built up since the transition to an all-Stage-3 fleet is not known. However, two limited studies prior to this transition show that land-use control measures around airports had not been fully implemented despite the airports' participation in FAA's program designed to prevent the development of new noncompatible land use. In one study this was true for 7 of 16 airports and in another study it was true for 6 of 10 airports. <ul style="list-style-type: none"><li>• How can communities be encouraged to adopt zoning and other land-use measures to restrict noise-sensitive development around airports?</li><li>• What, if anything, can the federal government do to help communities address this issue?</li></ul>

<sup>a</sup>See *Aviation and the Environment: FAA's Role in Major Airport Noise Programs* (GAO/RCED-00-98 Apr. 28, 2000) for a discussion of FAA's land-use initiative.

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## Agency Comments

We provided the Department of Transportation, the Environmental Protection Agency, the National Aeronautics and Space Administration, the Airports Council International-North America, the Air Transport Association of America, and the American Association of Airport Executives with copies of a draft of this report for their review and comment.

The Environmental Protection Agency, the National Aeronautics and Space Administration, and the American Association of Airport Executives provided no comments.

We received oral comments from the Department of Transportation, specifically from FAA's Office of Environment and Energy. These officials generally agreed with the facts in the report. They provided updated information on their MAGENTA model, which was used to estimate the number of people exposed to noise levels that FAA considers incompatible with airport operations. In the draft report, we noted that some of the data used in the model were not the most current and that FAA's estimates of the number of people exposed to incompatible noise levels may be affected by this limitation. FAA officials provided us with updated information on the population exposed to incompatible noise levels. They noted that two of four key data inputs to the model have been updated and that FAA is updating the other two. FAA agreed that the updated data would improve the accuracy of the data. We revised the report to reflect this information. FAA officials also provided us with technical comments, which we incorporated as appropriate.

The Airports Council International-North America provided oral comments. The Senior Vice President of Technical and Environmental Affairs complimented our staff on expertly capturing the complex issues raised by the subject. He clarified the Airports Council's position with respect to phasing out older, noisier aircraft. The draft report stated that the organization had recommended phasing out the operation of aircraft whose engines were technologically converted, or hushkitted, to comply with current standards. The Airports Council has called for retiring aircraft that are within 5 decibels of the Stage 3 standard rather than retiring an aircraft based on a design feature such as a hushkit. On a related note, the Airports Council believes that part of the reason for the continuing concern about noise is that these older aircraft are generally noisier and a significant number of them are still in operation. We revised the report to clarify their position on this subject. The Airports Council provided other technical comments, which we incorporated as appropriate.

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The Air Transport Association also provided oral comments. The Assistant General Counsel noted that we did a good job of capturing the important factors that went into the transition from Stage 2 to Stage 3. However, the Association cautioned that not all of the results would be directly applicable as the industry transitions from Stage 3 to Stage 4. In particular, the Association noted that the technological and economic circumstances are much different now than they were back in 1990, when the Congress mandated the transition to Stage 3. Although the report states that our objective is to provide a retrospective analysis of the transition to Stage 3, we agree that the transition to Stage 4 needs to be viewed apart from the transition to Stage 3. We revised the report to clarify this point. The Association also made other technical comments, which we incorporated as appropriate.

We conducted our review from January 2001 through August 2001 in accordance with generally accepted government auditing standards.

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As agreed with your office, unless you publicly release its contents earlier, we plan no further distribution of this report until 14 days after the date of this letter. At that time, we will send copies of the report to the appropriate congressional committees; the Secretary of Transportation; the Administrator, FAA; the Administrator, Environmental Protection Agency; and the Administrator, National Aeronautics and Space Administration. We will also make copies available to other interested parties upon request. Please call me at (202)-512-2834 if you have any questions about this report. Key contributors to this report are listed in appendix V.

Sincerely yours,



Gerald L. Dillingham, Ph. D.  
Director, Physical Infrastructure Issues

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# Appendix I: Development and Implementation of U.S. Aircraft Noise Standards

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In the United States, responsibility for aircraft noise standards resides with the Federal Aviation Administration (FAA). The Federal Aviation Act of 1958, as amended in 1968, gave FAA the authority to regulate aircraft noise through the aircraft type certification process. FAA can implement new aircraft noise standards through the standard federal rulemaking process. Under that process, FAA must consult with the Environmental Protection Agency, but the final decision lies with FAA. However, the Environmental Protection Agency may also initiate new aircraft standards by submitting proposed regulations to FAA, which FAA is required to initiate through the federal rulemaking process. As part of the federal rulemaking process, FAA must consider whether a proposed standard is economically reasonable, technologically practicable, and consistent with the highest degree of safety in air transportation or commerce.

Under the Federal Aviation Act, as amended, FAA issued regulations in 1969 that established noise standards for new designs of civil subsonic jet aircraft. Initially, these regulations prescribed noise standards that applied only to new types or designs of aircraft. In 1973, FAA amended its regulations to apply the noise standards to all newly manufactured aircraft, whether or not the aircraft design was new. In 1976, FAA prohibited any subsonic jet aircraft weighing over 75,000 pounds from flying into or out of U. S. airports after January 1, 1985, unless their engines had been modified or replaced to meet the new standards.<sup>1</sup> In 1977, additional amendments to the regulations established more stringent noise standards for all new aircraft, as well as the concept of noise “Stages.” Aircraft meeting the original 1969 standards were categorized as “Stage 2” aircraft; those meeting the more stringent 1977 standards were categorized as “Stage 3” aircraft; and aircraft meeting neither set of standards were categorized as “Stage 1” aircraft.

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<sup>1</sup>However, the Aviation Safety and Noise Abatement Act of 1979 directed FAA to grant exemptions from compliance until January 1, 1988, to jet aircraft with two engines and fewer than 100 passenger seats.

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## Transition to Current Noise Standard Mandated by Statute

Under the Airport Noise and Capacity Act (ANCA) of 1990, civil subsonic jet aircraft weighing more than 75,000 pounds that did not meet the Stage 3 standards were required to comply with these standards by December 31, 1999, or be retired from service in the United States.<sup>2</sup> Regulations implementing the transition went into effect on September 25, 1991. The regulations provided two options for the transition, which are described in table 2.

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**Table 2: Options for Compliance With Stage 3 Aircraft Noise Standards**

Option	Phased transition deadlines			
	December 31, 1994	December 31, 1996	December 31, 1998	December 31, 1999
1—Reduction in the percentage of Stage 2 aircraft in a carrier's fleet	25%	50%	75%	100%
2—Increase in the percentage of Stage 3 aircraft in a carrier's fleet	55%	65%	75%	100%

Source: 14 C.F.R. 91.865.

FAA stated that this combination of methods would result in significant cost savings for the industry while still preserving environmental gains. Since the greatest environmental gains would occur near the end of the phase-out period, according to FAA, there was no ultimate difference in the two approaches. FAA expected both approaches to achieve steady progress toward an all-Stage-3 fleet throughout the decade.

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## FAA Monitored Compliance Through Annual Progress Reports

Each domestic and foreign aircraft operator of large civil subsonic jet aircraft in the United States was required to submit an annual report on its progress toward compliance with the phased elimination of Stage 2 aircraft weighing over 75,000 pounds. Each report was required to contain information on the operator's fleet composition. Domestic carriers were required to provide initial compliance plans in 1992, followed by annual updates. Each airline had to provide FAA with the following information annually: (1) any Stage 2 aircraft added to its fleet; (2) any Stage 2 aircraft removed from U.S. operations and either transferred to another recipient

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<sup>2</sup>Under the statute, jet aircraft weighing 75,000 pounds or less may continue to operate without meeting the Stage 3 aircraft noise standards.

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or retired, destroyed, or put into storage; (3) any Stage 2 aircraft returned to or imported from a foreign source; (4) any Stage 2 aircraft modified to meet Stage 3 noise standards; (5) all Stage 3 aircraft meeting U.S. operations requirements; and (6) the date for achieving full compliance with Stage 3 noise standards.<sup>3</sup>

According to an FAA official, FAA monitored each aircraft operator's progress toward meeting the statutory compliance date of December 31, 1999. The agency also monitored domestic operators' progress in meeting their compliance plans through direct communications and provided for contact with foreign operators and foreign civil aviation officials to ensure that they were aware of and prepared to meet the statutory compliance deadline. FAA reviewed all annual reports to ensure accuracy and completeness and followed up by contacting operators when necessary. Compliance monitoring was an ongoing effort with the goal, according to an FAA official, of monitoring and reminding operators about the statutory compliance deadline. FAA is satisfied that all known affected operators are in compliance with the December 31, 1999, statutory requirements.

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## No Waivers Were Granted

The ANCA statute allowed a domestic carrier to apply for a limited waiver that would extend the date by which compliance was required. To be eligible for consideration, a petitioner was required to have a fleet mix of 85 percent Stage 3 aircraft by July 1, 1999, and show, among other criteria, that a waiver would be in the public interest. A petitioner was also required to show that a good faith effort had been made to comply. A plan, providing for compliance by December 31, 2003, was required.<sup>4</sup>

FAA received 10 petitions for waivers from the Stage 3 transition rule. No waivers were granted. One petitioner requested that it be allowed to operate Stage 2 airplanes after December 31, 1999; that petition was denied. The other nine petitioners requested permission to operate nonrevenue flights for purposes of Stage 3 modifications, storage, maintenance, and/or exportation. FAA notified these petitioners that it did not have the authority to authorize such operations under the provisions of the law. For a limited time, foreign carriers were also allowed to apply for a waiver from the final compliance deadline for transition to Stage 3

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<sup>3</sup>14 C.F.R. 891.875.

<sup>4</sup>49 U.S.C. 47528(6).

noise standards, but according to an FAA official, FAA received no requests for such waivers.

In November 1999, the Congress amended ANCA to allow the operation of Stage 2 aircraft in nonrevenue service after December 31, 1999, under specific conditions.<sup>5</sup> FAA chose to implement the provision by issuing special flight authorizations. An operator of a Stage 2 airplane that wanted to operate in the contiguous United States for any of the purposes listed in the revised statute had to apply in advance. Applications are due 30 days in advance of the planned flight and must provide the information necessary for FAA to determine that the planned flight is within the limits prescribed by law.

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## **Stage 3 Aircraft Noise Standards**

Figures 2 through 4 show the Stage 3 aircraft noise standards and the increases in noise allowed as aircraft weight increases.<sup>6</sup> As figure 2 illustrates, the noise standards for takeoff operations also vary with the number of engines.

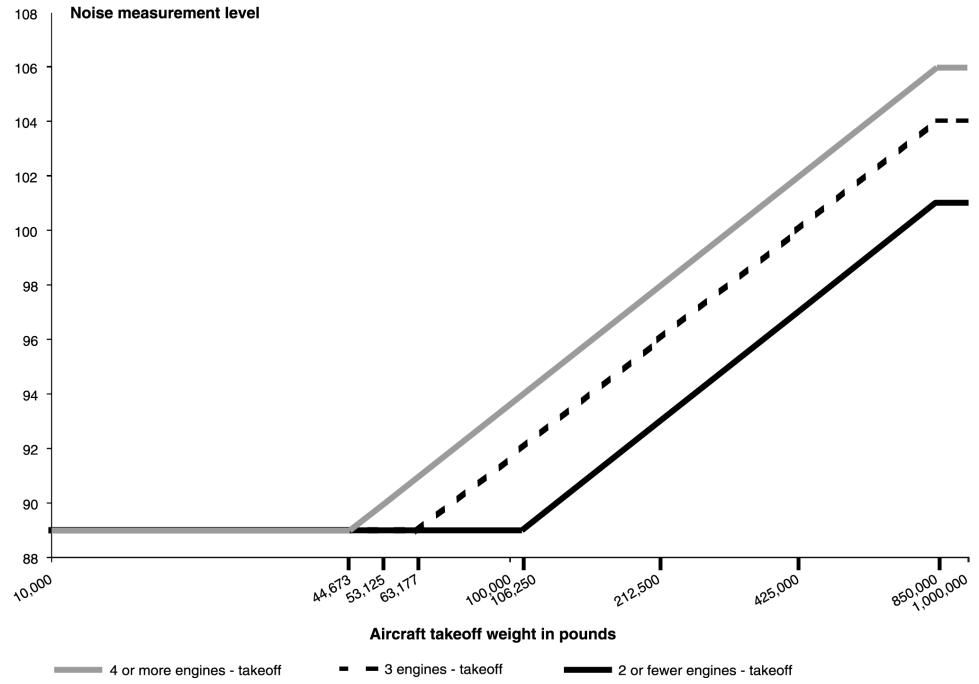
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<sup>5</sup>See Section 1000(a)(5) of P. L. 106-113.

<sup>6</sup>Aircraft must be tested in accordance with the conditions established in appendix A of 14 C.F.R. part 36. This appendix sets the test requirements for such things as weather conditions, test procedures, and the noise measurement systems to be used. Appendix B describes how to translate those measurements into a measure of the “effective perceived noise level,” which includes a correction for tones and takes into account the duration of the noise event. The noise standards are established in appendix C, and are defined in terms of the effective perceived noise level.

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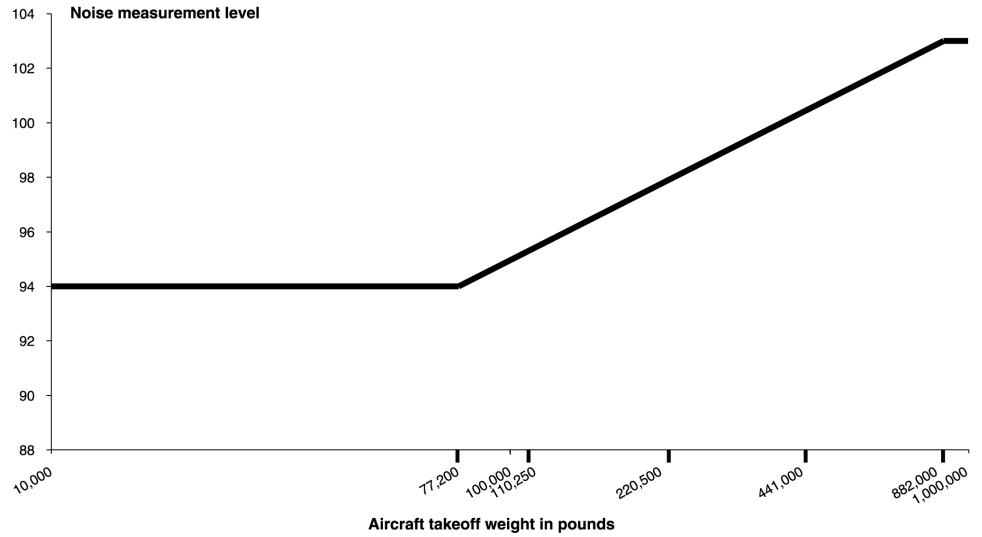
**Figure 2: Noise Standards for Stage 3 Aircraft by Number of Engines—Takeoff**



Note: The noise measurement level is defined in terms of the “effective perceived noise level,” which includes a correction for tones and takes into account the duration of the noise event. The weight scale in the figure is a logarithmic scale.

Source: GAO’s compilation of data from FAA.

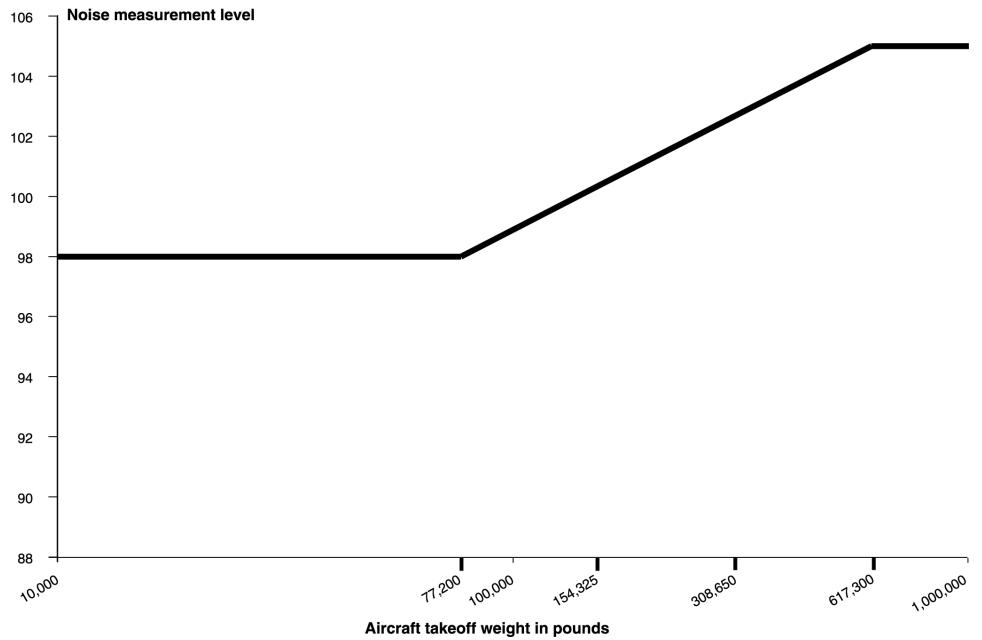
**Figure 3: Noise Standards for Stage 3 Aircraft Regardless of the Number of Engines—Sideline**



Note: The noise measurement level is defined in terms of the “effective perceived noise level,” which includes a correction for tones and takes into account the duration of the noise event. The weight scale in the figure is a logarithmic scale.

Source: GAO's compilation of data from FAA.

**Figure 4: Noise Standards for Stage 3 Aircraft Regardless of the Number of Engines—Approach**



Note: The noise measurement level is defined in terms of the “effective perceived noise level,” which includes a correction for tones and takes into account the duration of the noise event. The weight scale in the figure is a logarithmic scale.

Source: GAO's compilation of data from FAA.

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# Appendix II: Development of International Aircraft Noise Standards

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The International Civil Aviation Organization (ICAO) develops international noise standards to provide consistent aircraft noise standards across nations. ICAO, the international body charged with ensuring the safe and orderly growth of international civil aviation throughout the world, operates under the *Convention on International Civil Aviation*, ratified in 1947. Although not a regulatory body, ICAO promulgates standards and recommends practices for international civil aviation. According to the terms of the Convention, ICAO makes its decisions through an Assembly and a Council with various subordinate committees, commissions, and panels, including the Committee on Aviation Environmental Protection (CAEP), which conducts most of ICAO's technical environmental work. CAEP does its technical work through various working groups relying on the participation and technical expertise of its member countries.

The Assembly, composed of representatives from ICAO's 187 member countries, is ICAO's ultimate decisionmaking body. It meets at least once every 3 years to review ongoing work and set policy for the coming years. Each member country is entitled to one vote, and decisions of the Assembly are taken by a majority of the votes cast except when otherwise provided in the Convention. According to FAA, in practice, most Assembly decisions are made by consensus.

The Council, composed of representatives from 33 countries, is elected by the Assembly for a 3-year term. The Assembly chooses the members of the Council with representation from three categories: (1) major air transport countries, (2) countries making the largest contribution to the provision of air navigation facilities for international civil air navigation, and (3) countries from major areas of the world not represented by members selected in the first two categories.<sup>1</sup> Member nations are selected to represent only one of these three categories. The Council is the governing body that provides continuing direction to the organization's activities,

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<sup>1</sup>The 32nd session of the Assembly in 1998 elected the states listed below as members of the Council for the 1998-2001 period. The election process was divided into three parts, with the following states elected:

Part 1 – *States of chief importance to air transport*: Australia, Brazil, Canada, France, Germany, Italy, Japan, the Russian Federation, the United Kingdom, and the United States.

Part 2 – *States that make the largest contribution to the provision of facilities for international air navigation*: Argentina, China, Colombia, Egypt, India, Mexico, the Netherlands, Nigeria, Norway, Saudi Arabia, and Spain.

Part 3 – *States ensuring geographic representation*: Algeria, Botswana, Cameroon, Cuba, Indonesia, Kenya, Lebanon, Pakistan, Panama, Senegal, Slovakia, and Uruguay.

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and it is responsible for adopting standards and recommended practices that govern all aspects of international civil aviation, ranging from safety and security to the noise and environmental aspects of aircraft operations. Proposed new aviation standards submitted to the Council require a two-thirds majority vote for adoption. After adoption, the standards are submitted to the member countries. The new standards become effective unless a majority of the member countries disapprove them through the Assembly. According to FAA, the Council also reaches most decisions through consensus. If a government organization within a member country, like FAA, certifies that an aircraft meets ICAO's standards, then all ICAO member countries must recognize that certification as valid. An ICAO member that does not adopt ICAO's standards must provide a written explanation to ICAO. If an ICAO member files such an explanation, other ICAO members are absolved from their obligation to recognize that country's certification of aircraft—they do not have to allow such aircraft into their country. Furthermore, if a member country fails to file a written notification, it will be in default of its obligation, and will risk the exclusion of its aircraft from travel in other ICAO member countries and the loss of its voting power in the Assembly and Council.

The Council accomplishes its work through committees and commissions that provide technical expertise for the review of issues the Council considers. CAEP conducts most of ICAO's environmental work, from reviewing aircraft noise issues and developing aircraft noise standards and recommended practices to recommending actions for the Council's adoption. CAEP is responsible for striking a balance among conflicting objectives for aircraft technical specifications, since every change made to an aircraft or its engines can affect its safety performance, emissions performance, noise level, and fuel efficiency. CAEP is the only committee that reports directly to the Council, unlike other ICAO technical groups, which report through either the Air Navigation Commission or the Air Transport Committee.<sup>2</sup> CAEP's membership is established by the Council and specific members are nominated by member nations and international

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<sup>2</sup>The primary mandate of the Air Navigation Commission is to recommend to the ICAO Council the most appropriate course of action in the process of developing and amending aviation standards and recommended practices. The Air Navigation Commission is composed of 15 technical experts appointed by the Council on the basis of their experience and expertise. Although the experts are nominated by member nations, they are independent experts rather than official representatives of their respective nations. The Air Transport Committee advises the Council on problems associated with air transport. Membership is open to any Council member willing to take an active and continuous part in the Committee's work.

observer organizations. CAEP is currently composed of experts from 19 ICAO member countries and observers from 12 organizations representing all major sectors of the aviation industry, including airports, airlines, aircraft manufacturers, environmental organizations, and two countries (Norway and Greece). The U.S. government, industry, and environmental representatives participate in or observe CAEP.

## **ICAO's Development of Aircraft Noise Standards**

ICAO develops aviation standards, including aircraft noise standards, through the amendment of annexes to the Convention on International Civil Aviation.<sup>3</sup> The main parts of each annex are the international standards and recommended practices. A standard is defined as a specification, the uniform application of which is necessary for the safety or regularity of international civil air navigation. A recommended practice, on the other hand, is defined as a specification, the uniform application of which is desirable in the interest of safety, regularity, or the efficiency of international civil aviation.

As figure 5 shows, proposals to amend or add either new standards or recommended practices may come from any ICAO members, observers, committees, commissions, panels, or other ICAO units. The Council establishes CAEP's work program and must approve the initiation of any work to amend or add new environmental standards. According to the Council's mandate, CAEP imposes conditions for adopting environmental standards. The proposed standard must be economically reasonable, technologically feasible, and environmentally beneficial. Proposed new standards recommended for adoption by CAEP are submitted to the Council, where a two-thirds majority vote is required for adoption. Depending on the issue, the Council refers CAEP's recommendations to either the Air Navigation Commission, the Air Transport Committee, or other appropriate body for review before acting on the recommendations. Technical standards are adopted by the Council unless a majority of ICAO members disapprove them. Policy issues are usually forwarded by the Council to the Assembly for resolution, where a majority vote is required for final action. If any member nation finds it impossible to comply, the country is required to notify ICAO of any differences that will exist at the time the standards or practices take effect. ICAO then publishes those notifications of differences in supplements to the annexes. For policy issues covered by an Assembly resolution, there is no requirement to file a

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<sup>3</sup>An annex is an appendix to the main part of an agreement.

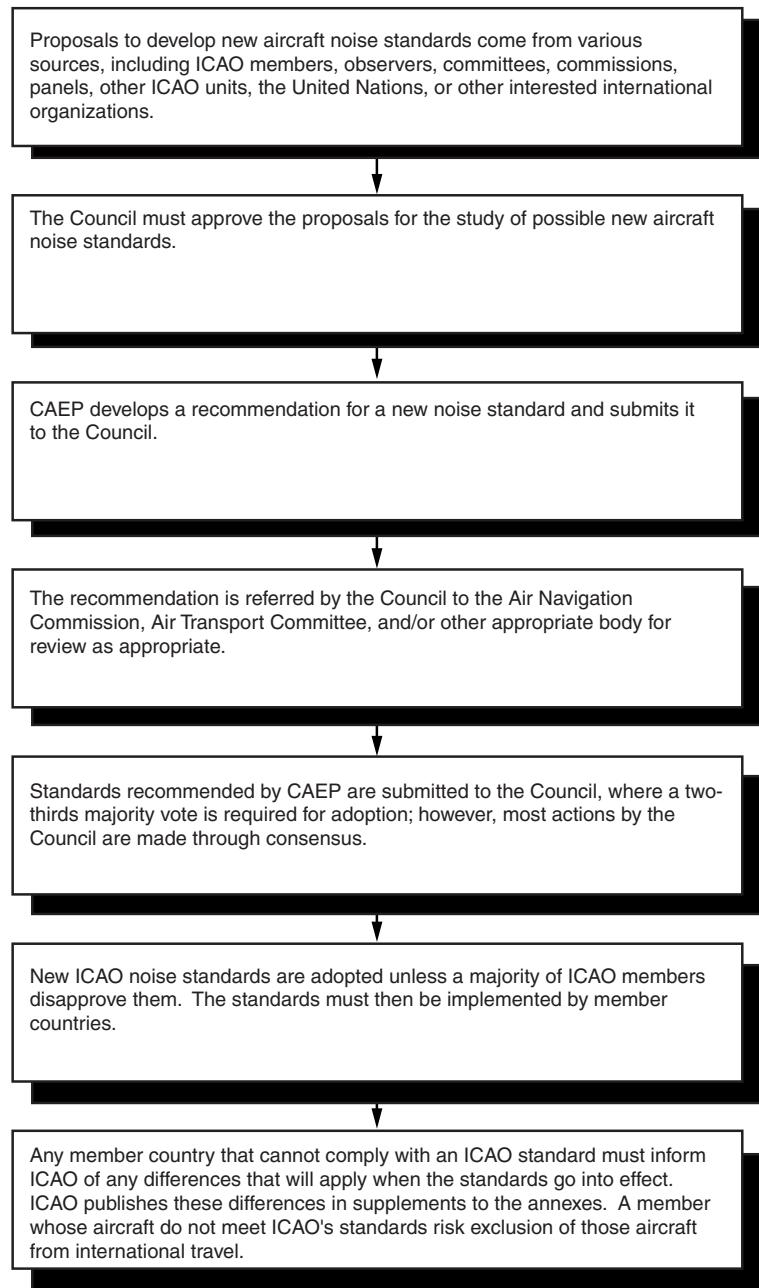
difference if the nation chooses not to comply with any or all of the provisions.

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## Appendix II: Development of International Aircraft Noise Standards

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**Figure 5: Developing and Implementing New Aircraft Noise Standards in the International Civil Aviation Organization**



Source: GAO's compilation from ICAO documents.

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International aircraft noise standards adopted by ICAO are published as Chapters in Volume I of Annex 16 to the *Convention on International Civil Aviation*. Chapter 2 of Annex 16, Volume I, contains the aircraft noise standards that apply to jet aircraft designed prior to October 1977. Chapter 3 contains more stringent noise standards that apply to aircraft designed after that date. Chapter 4 contains ICAO's new noise standards, adopted in June 2001. The primary purpose of establishing noise standards is to reduce aircraft noise. This noise reduction, when combined with other measures, is intended to reduce the number of people exposed to significant levels of aircraft noise.

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## **ICAO's Consideration of New Aircraft Noise Standards**

On January 17, 2001, CAEP recommended the adoption of new aircraft noise standards. The new standards, incorporated into a Chapter 4 of Annex 16, Volume 1, are 10 decibels quieter than the Chapter 3 standards, on a cumulative basis, from aircraft noise measurements at takeoff, approach, and sideline.<sup>4</sup> The Chapter 4 standards apply to new aircraft designed after January 1, 2006. The new standards do not apply to the current fleet or to current designs in production. On June 27, 2001, the ICAO Council unanimously approved the adoption of the new Chapter 4.

CAEP also recommended procedures for recertifying existing aircraft to meet the new standards. According to FAA, based on the cost and environmental impact information reviewed by CAEP, there was unanimous agreement within CAEP that there should be no global phaseout of existing aircraft. The committee remained divided, however, over whether or not to recommend a regional phaseout of existing aircraft. The Assembly will consider this issue at its meeting from September 25 to October 5, 2001. CAEP also endorsed a balanced approach to noise management, which is an airport-by-airport approach to managing noise using all available measures—aircraft noise reduction, land use planning and noise mitigation measures, noise abatement operational procedures, and operating restrictions on aircraft—to address specific noise problems in a very targeted way.

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<sup>4</sup>Sideline noise is measured at a point parallel to the flight path where the noise level is the greatest.

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# Appendix III: Objectives, Scope, and Methodology

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Because the United States is moving to a new, more stringent noise standard, we were asked to provide a retrospective analysis of the transition to current aircraft noise standards, including a discussion of expectations, results, and issues raised by the transition.

To identify expectations and results and to discuss issues raised by the transition of existing aircraft to the current U.S. noise standards, known as “Stage 3,” we (1) reviewed the legislative history of the Airport Noise and Capacity Act of 1990; (2) conducted interviews and gathered information from the following agencies and organizations: FAA, the Environmental Protection Agency, the National Aeronautics and Space Administration, the International Civil Aviation Organization, the Aerospace Industries Association, the Airports Council International-North America, the Air Transport Association of America, Inc. (hereafter referred to as the Air Transport Association), the American Association of Airport Executives, the Cargo Airline Association, the General Aviation Manufacturers Association, the National Association of State Aviation Officials, the National Business Aviation Association, the Natural Resources Defense Council, Pratt & Whitney, and the Regional Airline Association; (3) conducted a literature search through the Internet and Lexis-Nexis and reviewed key documents; (4) discussed the Model for Assessing Global Exposure to the Noise of Transport Aircraft with FAA to assess the reliability of the model’s estimate of the number of people living in areas exposed to incompatible noise levels; (5) developed our own model for estimating the costs to airlines of moving to the current aircraft noise standards; and (6) compared results with expectations and analyzed the results to identify issues raised by the transition. We provided a written summary of our findings to the organizations listed under (2) above for their review and comment before completing the final draft report.

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# Appendix IV: Methodology for Estimating Airlines' Costs to Transition to Stage 3 Aircraft Noise Standards

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We identified two recent estimates—one by the Air Transport Association<sup>1</sup> and one by Pratt & Whitney<sup>2</sup>—of the costs to airlines to comply with current Stage 3 aircraft noise standards. Because both of these estimates attributed the full cost of new replacement aircraft to the noise requirements, we developed an estimate that focuses on the costs of the transition that are directly attributable to compliance with the noise standards (i.e., the cost of hushkitting or the incremental cost of financing a new aircraft early, whichever was lower). We estimated that the cost to comply with Stage 3 noise standards ranged from \$3.8 billion to \$4.9 billion in 2000 dollars.

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## Two Estimates Include the Full Cost of Replacement Aircraft

In 1999, the Air Transport Association commissioned the Campbell-Hill Aviation Group, a consulting firm, to estimate the airlines' costs to transition to the current Stage 3 aircraft noise standards.<sup>3</sup> Campbell-Hill estimated that the costs attributable to compliance were about \$32 billion in 1999 dollars, not including fleet growth. This estimate covers the cost of replacing Stage 2 aircraft (including both the interest expense associated with the acquisition of replacement aircraft and the depreciation for new aircraft acquired prior to the end of the useful lives of the aircraft they replaced) and the cost of hushkitting or reengining Stage 2 aircraft to meet Stage 3 standards. Air Transport Association officials said that some airlines, depending on their fleet composition, were faced with significant commercial risk in deciding how to comply with ANCA if they chose to wait for the development and certification of the now retrospectively less expensive hushkits. These kits are now readily available, but the airlines did not have the advantage of a perfect forecast of the availability of hushkit solutions for their aircraft affected by the phaseout. In cases where aircraft replacement actually was chosen during the phase-out

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<sup>1</sup>The Air Transport Association is a trade organization for major U.S. airlines.

<sup>2</sup>Pratt & Whitney designs and manufactures engines for commercial, military, and general aviation aircraft.

<sup>3</sup>In 1990, the Air Transport Association originally estimated that the cost to U.S. airlines to transition to an all Stage 3 fleet, including aircraft purchased for fleet growth, would be about \$175 billion. According to an association official, this figure includes the costs to the airlines that were directly attributable to the Stage 3 transition, as well as the costs of additional investments made by the air carriers. Since details of the methodology used to generate this estimate are no longer available, the Air Transport Association commissioned a new analysis by the Campbell-Hill Aviation Group to provide a current estimate of the costs after the transition. The Campbell-Hill analysis estimated that with the inclusion of fleet growth, the airlines' costs were about \$110 billion in 1999 dollars.

period, the Campbell-Hill analysis gives the airlines credit for the entire replacement cost of a new aircraft because of this commercial risk, even if hushkitting would have been an option.

Pratt & Whitney also estimated the cost to the airlines of making their fleets compliant with the Stage 3 noise standards—about \$15.5 billion in 1999 dollars. About \$4 billion of this estimate was attributed to the cost of converting existing aircraft to meet the standard. The remaining \$11.5 billion was the estimated cost to purchase replacement aircraft to comply with Stage 3 noise standards. The estimate includes the full purchase price of the new aircraft—an average price of \$40 million each for 287 narrow-body jets designated as being replaced because of the phaseout of Stage 2 aircraft. This represents one-third of the total number of narrow-body jets that were replaced between 1990 and 1999.<sup>4</sup>

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## **Cost to Airlines of the Transition Ranged From \$3.8 Billion to \$4.9 Billion**

We developed our own estimate of the airlines' transition costs directly attributable to compliance with the Stage 3 noise standards. We estimated that the appropriate cost directly attributable to requirements to comply with the Stage 3 noise standards ranged from \$3.8 billion to \$4.9 billion in 2000 dollars. We determined that the appropriate cost that could be attributed to compliance with the Stage 3 noise standards was either the cost for the conversion of an aircraft—the cost to retrofit an aircraft with a hushkit—or the incremental capital cost to finance the early purchase of a replacement aircraft, whichever cost was lower.

Since hushkitting was expected and proved to be available for almost all types of aircraft,<sup>5</sup> when the airlines chose more costly methods to achieve compliance—such as replacing the engines or purchasing new aircraft—we attributed that choice to other economic reasons or benefits, such as

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<sup>4</sup>Pratt & Whitney assumed that one-third of the narrow-body aircraft replaced in the 1990s were replaced because of the Stage 2 phaseout. They assumed that the others were replaced for economic reasons.

<sup>5</sup>Hushkits were not available for five types of aircraft (16 aircraft in total), primarily Boeing 720s. The primary reason for this was that only a few of these older aircraft were in existence and they were to be retired soon. Thus, there was no demand for the development of a hushkit for them.

In addition, while a hushkitting alternative known as the Raisbeck method was less costly, it could only be applied to 727s and was not available until 1996. Many airlines had to plan for ANCA well before the Raisbeck method was available. We only used the cost of the Raisbeck method when it was actually used to comply with Stage 3 noise standards.

improved fuel efficiency, lower maintenance costs, and tax advantages. For example, changing an aircraft's engines instead of hushkitting them would provide added fuel benefits not available simply by hushkitting the engines.<sup>6</sup>

To develop our estimate, we purchased data from AvSoft Limited, which provided the list of Stage 2 aircraft over 75,000 pounds in the U.S. fleet on November 5, 1990, the day that ANCA was passed. Using the 1990 database, we identified 2,372 Stage 2 aircraft in the U.S. fleet as of that date. Matching the AvSoft database to 2001 FAA data, we were able to directly identify 1,051 aircraft as being hushkitted (or reengined) and still in the fleet. For 689 of these 1,051 aircraft, FAA data indicated the exact hushkit used on the aircraft by Supplemental Type Certificate code.<sup>7</sup> The FAA data indicated that another 362 of these 1,051 aircraft had been hushkitted or reengined but did not identify the exact hushkit used or indicate whether the aircraft had been reengined. For these 362 aircraft, since we did not know the exact hushkit used, we used the average of the cost for all the hushkits available for that model aircraft. In addition, we found that another 272 aircraft were Stage 3, so most likely had been hushkitted or reengined as well, although there was no direct match (the average cost of all hushkits available was also used for these 272 aircraft). Thus, we determined that at least 1,323 aircraft were modified (primarily hushkitted) to meet Stage 3 standards.

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<sup>6</sup>Air Transport Association officials noted that our approach differs from that of the Campbell-Hill study, which took into account the cost of replacing an aircraft rather than hushkitting it even when the replacement cost was greater than the hushkitting cost. The officials also said that there was risk involved to the airlines in waiting for the full development of hushkit technology.

<sup>7</sup>Supplemental Type Certificate codes are used by FAA to identify types of hushkits.

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**Appendix IV: Methodology for Estimating  
Airlines' Costs to Transition to Stage 3  
Aircraft Noise Standards**

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**Table 3: Methodology for Estimating the Cost to Meet Stage 3 Noise Standards**

<b>How aircraft met Stage 3 noise standards</b>	<b>Type of cost used in estimate</b>	<b>Number of aircraft</b>
Hushkitted or reengined <sup>a</sup>	Hushkit cost	1,323
Replaced	Hushkit cost, capital cost (if less than hushkit cost), or no cost (if aircraft beyond retirement age)	1,049
<b>Total</b>		<b>2,372</b>

<sup>a</sup>Of these aircraft, 1,051 were verified with FAA data to have been hushkitted or reengined. The other 272 were known to be either hushkitted or reengined because the most recent aircraft record indicates they are Stage 3 aircraft.

Source: GAO.

We developed cost estimates for the remaining 1,049 aircraft. We found that 386 aircraft were beyond retirement age on December 31, 1999. To make this judgment, we assumed that the typical life span of a passenger aircraft was 30 years, while the typical life span of a cargo aircraft was 40 years.<sup>8</sup> We assigned a hushkitting cost of zero to these aircraft. Next, we assumed that the cost of replacing an aircraft earlier than it would have otherwise been retired was the incremental cost of retiring the aircraft early—that is, the cost of borrowing the capital for the replacement aircraft earlier than would have normally occurred.<sup>9</sup> In 54 cases, we found that the aircraft were so close to retirement that the lowest cost option to comply with Stage 3 noise standards was the cost of capital expended before the anticipated retirement date to purchase a new aircraft. Lastly, for 611

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<sup>8</sup>According to our database, 26 years was the approximate average age of passenger aircraft. We rounded this figure up to 30 years to be conservative. Additionally, according to our database, 31 years was the average age of cargo aircraft. We rounded up from the average cargo aircraft age of 31 years to 40 years because 41 years was the maximum age of cargo aircraft and cargo aircraft typically fly many fewer cycles (a cycle is defined as one departure and landing of an aircraft) per day than passenger aircraft. Cargo aircraft therefore typically have longer life spans in years, although their life span measured in cycles are frequently similar.

<sup>9</sup>If the interest cost associated with replacing an aircraft early exceeded the cost of hushkitting an aircraft, we used the hushkit value. We did not include the cost savings associated with a new aircraft due to factors such as better fuel economy or a smaller crew. Including these factors likely would have decreased our estimate of the cost to the airlines slightly. We estimated that the cost of capital to the airline industry in 1999 was 7.8 percent. Our capital cost estimate was calculated using a weighted average of the costs of receiving financing from both the debt and equity markets where the weights are the proportion of total capital obtained from each. This estimate relied on information from Value Line, a common financial information source, for a representative firm (United Airlines) in the airline industry.

aircraft, we determined that the cost of hushkitting was an appropriate estimate for the cost of complying with ANCA because the incremental capital cost to finance the early purchase of aircraft was greater.

To estimate the cost of hushkitting an aircraft, we obtained data on hushkit base prices or a range of base prices,<sup>10</sup> installation costs, additional maintenance costs and hours, and performance gains or losses from hushkit manufacturers. These data were generally available by aircraft model type. We applied the actual hushkit cost, or range of costs, for a particular model of aircraft and the cost of installing the hushkit. For the aircraft whose specific hushkit model cost data we could not obtain, we applied the average cost, or range of costs, of those hushkits available for the aircraft model and type.

Because all hushkit manufacturers reported that increased maintenance was negligible, we did not include any cost in our estimate for changes in maintenance once an aircraft was compliant with Stage 3 noise standards. In addition, we did not include costs for downtime to install the hushkit. Although several airlines stated that hushkitting could not be scheduled during regular maintenance, we only received downtime cost information from one airline. An Air Transport Association official indicated that such information was not available for other airlines because of business confidentiality concerns. The one airline estimated that the cost to their business as the result of downtime amounted to \$31 million, about 7 percent of the total cost to hushkit their fleet. As a result, our estimate of the cost to the airlines to meet Stage 3 noise standards may be slightly higher if information on downtime costs was universally available.

Generally, hushkit manufacturers also reported that performance changes after an aircraft was hushkitted were negligible, so we did not include a cost estimate of these factors in our calculations. Some hushkit manufacturers, however, did report slight speed decreases, weight

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<sup>10</sup>The range of the estimate is due to the availability of different hushkitting options for some types of aircraft (we could not be certain which option was selected for an individual aircraft).

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**Appendix IV: Methodology for Estimating  
Airlines' Costs to Transition to Stage 3  
Aircraft Noise Standards**

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increases, and/or fuel burn increases. The use of engine upgrades for Boeing 747 aircraft to meet Stage 3 noise standards also resulted in slight fuel burn increases.

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# Appendix V: GAO Contacts and Staff Acknowledgments

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## GAO Contacts

Gerald L. Dillingham (202) 512-3650  
Belva Martin (202) 512-4285

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## Staff Acknowledgments

In addition to those named above, Beverly Ann Bendekgey, David K. Hooper, Arthur L. James, Kieran E. McCarthy, Mark E. Stover, and John A. Thomson made key contributions to this report.

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